

Slope/Shoreline Stabilization

Description

This BMP addresses structures which stabilize shorelines and slopes that cannot be stabilized with vegetation. Structures included in this BMP are: revetments, gabions, seawalls, bulkheads, groins, breakwaters and retaining walls. Typical applications of each of these structures are included in this BMP. Note that some of these structures are also used to stabilize stream banks. For additional information on these and other practices which can be used to stabilize stream banks, see the Stream Bank Stabilization BMP.

Permits for the construction of slope/shoreline stabilization practices will be required by the Department of Natural Resources, Land and Water Management Division if the structure is below the ordinary high water mark of a lake (or stream), floodplain or wetland. In some situations, both MDNR and U.S. Army Corps of Engineer permit requirements will need to be met.

Other Terms Used to Describe

Breakwalls
Bulkheads
Gabions
Groins
Retaining Walls
Revetments
Seawalls

Pollutants Controlled and Impacts

These practices protect the shorelines of watercourses by stabilizing embankments, thus limiting the erosion of soils and their associated particles into a watercourse.

Application

Land Use

This practice is applicable to all land uses.

Soil/Topography/Climate

The type of shoreline stabilization method used will vary depending upon the soils, slope of the land, groundwater characteristics, and the climatic conditions of the area. Their use is very important in areas where there are steep slopes, highly erodible soils, and where conditions can significantly increase or create erosion (i.e. areas of flash floods, strong winds and lake shorelines).

Special consideration should be given to the design and use of structures that will be susceptible to the forces of ice movement. Ice action has been shown to weaken, dislocate, and destroy improperly designed and installed structures.

When to Apply

Slope/shoreline stabilization structures should be installed prior to or immediately after disturbing erodible soils. Seasonal limitations exist for the construction of several of these structures, some of which are included in the specifications.

Where to Apply

Apply this BMP in areas where there is active or foreseeable erosion of the soils adjacent to a watercourse or wetland, and/or on steep slopes. Note that the construction and installation of these structures should not result in encroachment into the watercourse or wetland.

Relationship With Other BMPs

Areas up-slope of these structures should be stabilized with vegetation following the Seeding and Mulching or Sodding BMPs. In some instances, Diversions can be used to divert water away from these structures while they are being developed. Geotextile Filters are often used under these structures to filter sediment.

Specifications

General Considerations:

All slope/shoreline stabilization structures should be designed by licensed professional engineers, or other persons trained and experienced in their design.

1. All slope/shoreline stabilization structures should be free of sharp edges and protruding metals.
2. All structures require a site visit to determine the appropriate structure. During a site visit:
 - determine the soil texture and its inherent stability
 - determine the normal and storm surge water elevations
 - measure the length and (where appropriate) height of the area
 - consider the elevation of the proposed location for the new structure in comparison to the elevation of the existing shoreline
3. When designing structures, always try to follow the contour of the existing shoreline.

Revetments:

Revetments are stone, rock, interlocking blocks, gabions (see below), stacked bags (filled with sand or grout), or special mats, which are placed at the toe of a bluff to protect against storm/wave action. Revetments are cost effective, beneficial to the affected property owner, and do little or no harm to a lake environment *provided* the revetment material is clean, stable, and tied to existing structures and/or the shore.

General Considerations:

1. The three basic components of a revetment are the armor layer which absorbs the wave energy, the underlying filter layer supporting the armor layer, and the toe protection to prevent displacement of the armor units. All components should be designed simultaneously.

2. The stability of a revetment depends on the underlying soil conditions and should therefore be constructed on a stabilized slope. Erosion may continue or accelerate on an adjacent shore if it was formerly supplied with material eroded from the now protected area.
3. Slopes steeper than two horizontal to one vertical (2:1) are generally not suitable for revetments.

Design and Construction:

1. Riprap design and installation should be done following specifications in the Riprap BMP. Upon Department approval, consider installing fish habitat structures in conjunction with rock rip-rap to both stabilize an embankment and improve fish habitat.
2. Inter-locking blocks and honeycomb-shaped plastic sections which are backfilled with soil have been used successfully on steep slopes. The manufacturer's/suppliers listing in the Appendix of the "Guidebook to Best Management Practices for Construction Sites and Urban Areas" includes companies which carry these type of products.

Gabions:

Gabions are flexible woven-wire or plastic baskets composed of two to six rectangular cells filled with stone. They can be used in lakes and steep shorelines (or where river flow is such that riprap will not hold). The following is modified from "Guidelines for Soil Erosion and Sediment Control," Connecticut, 1985.

General Considerations:

Since gabions are used where erosion potential is high, construction must be sequenced so that the gabions are put in place with the minimum possible delay. Disturbance of areas where gabions are to be placed should be undertaken only when final preparation and placement of the gabions can follow immediately behind the initial disturbance. Always work at the low lake level (or low stream flow level).

Design:

Gabions may be used when all the following conditions are met:

- a. The design storm, riprap size and location, filter and quality criteria for riprap are met.
- b. The design water velocity does not extend beyond that given in Table 1, below.

Table 1
Design Water Velocity

Gabion Thickness (ft.)	Maximum Velocity* (ft./sec.)
1/2	6
3/4	11
1	14

*Maximum velocity is the velocity at the gabion (not, for example, the mean stream velocity).

Source: U.S. Department of Agriculture, Soil Conservation Service, Storrs, Connecticut.

- c. The Manning's "n" value used for gabions shall be 0.025.
- d. The pH of the soil and water is above 5, and the soil water resistivity is more than 4,000 ohms/cm, or plastic coated gabions shall be used.
- e. A filter is required unless the gabion has a thickness of at least three times the D₅₀ size of the rock used to fill the gabions.
- f. The rock used to fill the gabions shall be larger than the gabion mesh opening.
- g. Manufacturer's specifications are followed.

Construction:

1. Each gabion should be assembled by binding together all vertical edges with a continuous piece of connecting wire looped twice around the vertical edges with a coil approximately every four inches, except the mattress type where the coil should be approximately every three inches. Empty gabion units should be set to line and grade as shown on the plans. Connecting wire should be used to join the units together in the same manner as described above for assemble. Internal tie wires should be uniformly spaced and securely fastened in each outside cell of the structure. When gabions are being placed as slope protection or channel lining, the internal tie wires may be deleted.
2. Care should be taken when placing aggregate to assure that the sheathing on PVC-coated gabions will not be broken or damaged.

3. A standard fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and to maintain an alignment. After a gabion has been filled, the lid should be bent over until it meets the sides and edges. The lid should then be secured to the sides, ends and diaphragms with the connecting wire in the manner described above for assembling.
4. When the mattress type gabions are placed on 1.5:1 (or steeper) slope, steel stakes should be driven through the gabion along the top edge, as necessary, to hold the structure in place. Manufacturer's directions should be followed closely.

Seawalls and Bulkheads:

A seawall is a structure that is built to protect the landward side of a slope from damaging wave action or currents. Seawalls may be constructed with concrete, steel sheet piles or wood. Bulkheads have two functions. The first is to retain or prevent sliding of material seaward, and the second, to protect the upland against damage from wave action. The effects of seawalls and bulkheads on the entire reach of shoreline (or stream edge) must be evaluated.

General Considerations:

1. If the adjacent property has a seawall, a similar seawall in height and location should be used. It should tie into existing adjacent walls.
2. If the adjacent property is not seawalled, the proposed wall should tie into the shoreline and include tie backs into the upland. Tie backs should be rippapped at the shoreline to prevent erosion of adjacent properties.

Design:

1. The structure should be located and designed such that the structure will not create navigation safety hazards, debris traps, accelerated erosion of adjacent property, or any other problems.
2. The design should be appropriate for the site. Consider using materials similar to adjacent property owners. This will make the water line look more aesthetically pleasing.
3. Tie-backs must be designed to prevent erosion from water flow around the sides. Typical tie-backs extend 10 feet into the upland.
4. Bulkheads and seawalls that rise vertically well above a water or wetland surface may need to be equipped with ladders or escape measures in case of accidental falls by users.

Construction:

In general, for proper installation of steel or timber bulkheads, one-third of the wall should be above the lake bottom and two-thirds of the wall should be into the lake bottom.

Groins:

A groin is a shoreline protection structure which is usually situated perpendicular to the shore to trap soil for creating a beach on the up-drift side of the groin. These structures may consist of a single groin, or be combined with several groins to form a groin field. Careful design is needed to avoid adverse erosional effects on the down-drift side of a project.

General Considerations:

1. Groins by themselves will usually not provide adequate protection to the backshore area during a large storm. A wood retaining wall at the toe of the bluff may also be necessary to provide adequate protection.
2. Since groins may affect the "down-drift" area, the groin should be located and designed such that any erosion caused by the groin does not affect unprotected shoreline. Determine the new littoral transport direction by visual inspection of other groins in the vicinity, or review aerial photographs.
3. Spacing of groins depends on local wave energy and the amount of littoral drift. Groins should be spaced so that drift accumulates along the entire distance between the structures. (If the groins are too far apart, part of each compartment will be unprotected due to lack of accumulation. If the groins are too close together, not enough littoral material will accumulate in the compartments). As a rule of thumb, space groins from 1 - 1.5 times their effective length apart.

Design:

1. The proposed groin should not be longer than other groins in the vicinity.
2. Groins must be:
 - designed to cause the least damage to the down-drift side of the project
 - designed with no more than one foot above the current water level at the lakeward end
 - designed to extend into the face of the bluff or upland area
 - designed so that it is at least one-half of its length away from the property line. If this is not possible, then written consent must be obtained from the adjacent land owner.
 - constructed perpendicular to the shore

Groins constructed of wood or steel should extend $\frac{2}{3}$ of the length of the material below the beach or lake bottom.

Construction:

Construction should be perpendicular to shore and should be done according to the design.

Breakwaters:

The function of breakwaters is to intercept incoming waves, dissipate their energy, and thus form a low-energy zone on the landward side. This reduction in wave energy reduces the ability of sediment transport. Sand moving along the shore is therefore trapped behind the structures and accumulated. Breakwaters are often placed as segmented structures that allow for the protection of longer reaches of shoreline for less cost.

Design:

The design and construction of breakwaters is usually done by or with the supervision of the U.S. Army Corps of Engineers.

Retaining Walls:

Retaining walls are used to stabilize steep slopes. They may be made using riprap, railroad ties, gabions or other appropriate materials.

Maintenance

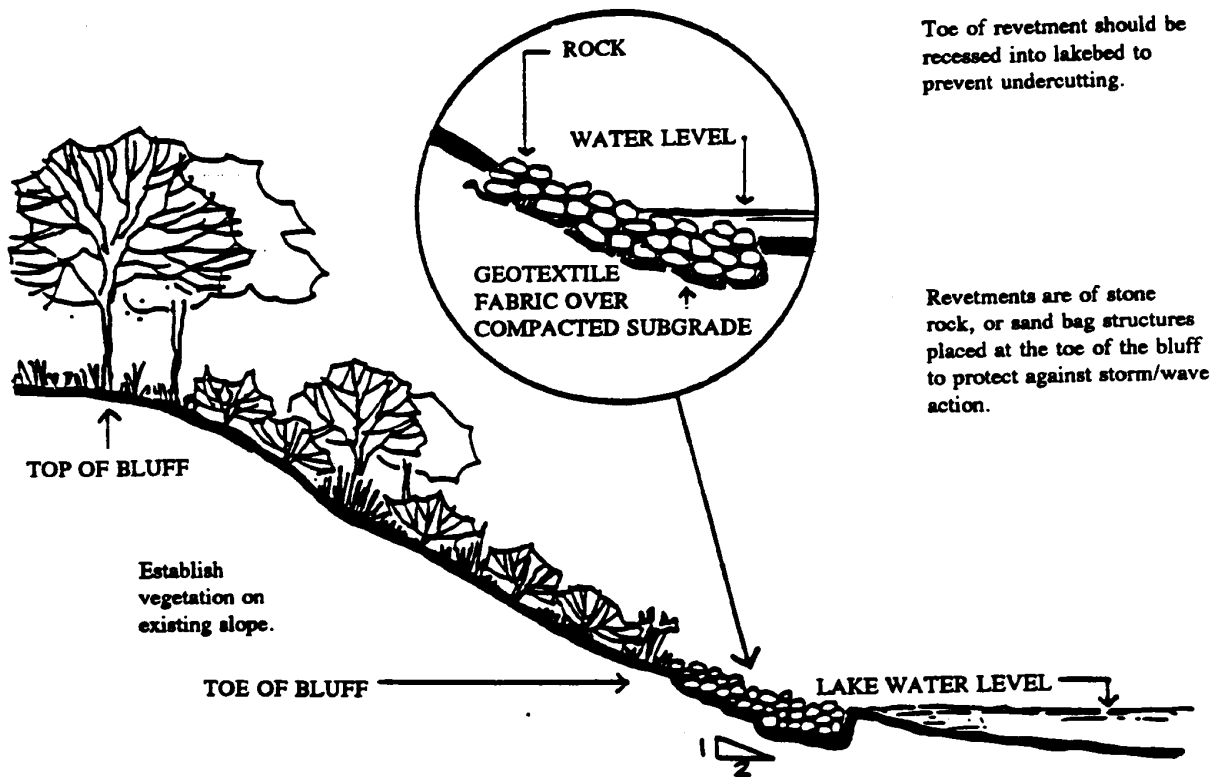
Annual inspections are important to check and re-align structures for functionality and safety. Check for hazardous materials or conditions which may have resulted from flooding, ice, or other weather conditions (i.e. look for sharp metal objects, signs of piping around structures, animal burrows, shifted and/or damaged materials within the structure, etc.).

Exhibits

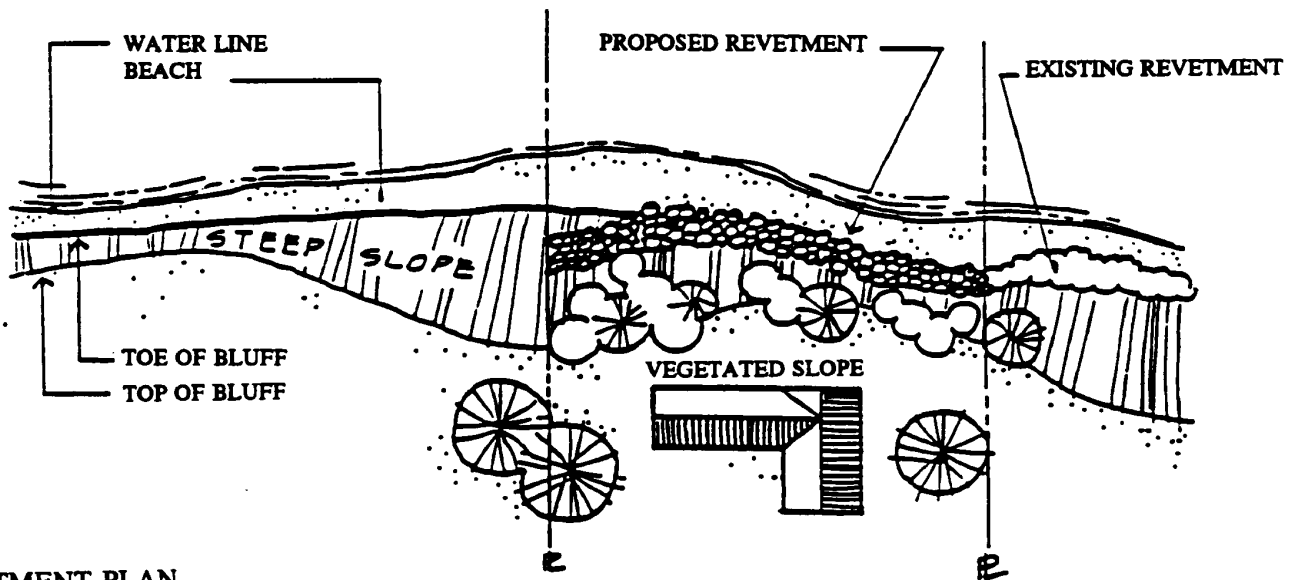
- Exhibit 1: Typical Revetment. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.
- Exhibit 2: Gabions. Virginia Soil Erosion and Sediment Control Handbook. 1980.
- Exhibit 3: Seawalls: Four Situations and the Type of Structures Required. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.
- Exhibit 4: Groins. Michigan Department of Natural Resources, Land and Water Management Division. Construction Project Evaluation Manual.
- Exhibit 5: Retaining Wall. Michigan Soil Erosion and Sedimentation Control Guidebook. 1975.

Exhibit 1

Typical Revetment



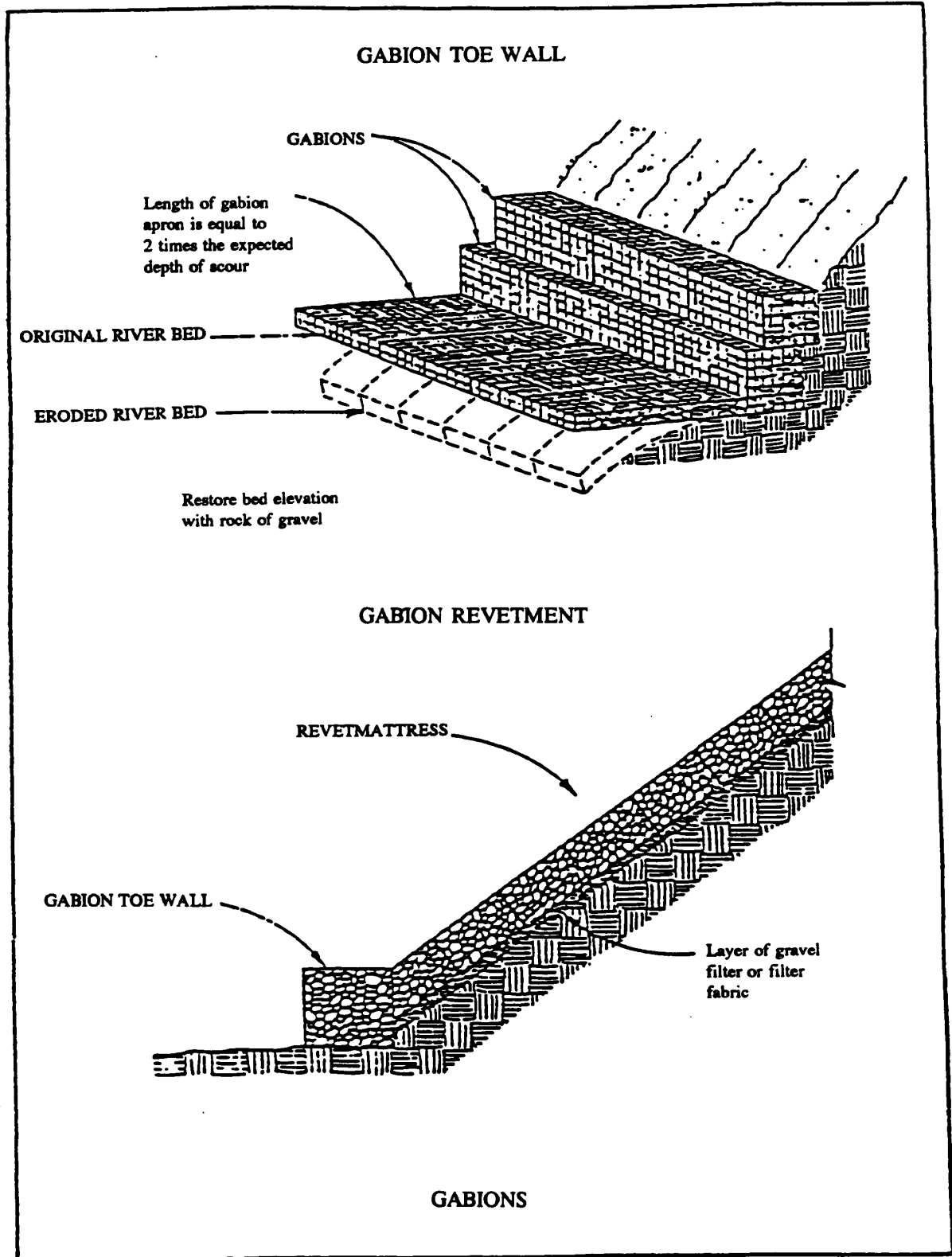
TYPICAL REVETMENT SECTION



REVETMENT PLAN

Source: Construction Project Evaluation Manual. MDNR, Land and Water Management Division.

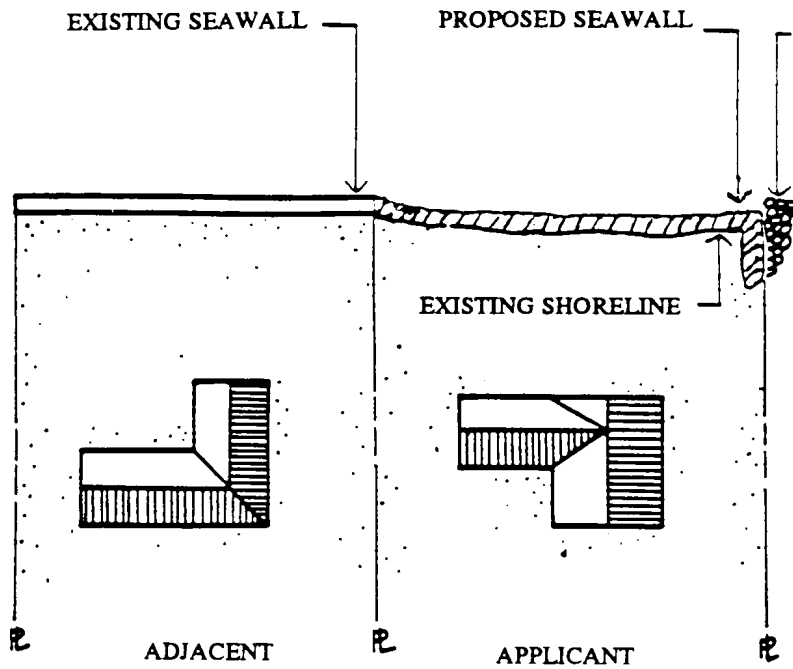
Exhibit 2
Gabions



Source: Virginia Soil Erosion and Sediment Control Handbook, 1980.

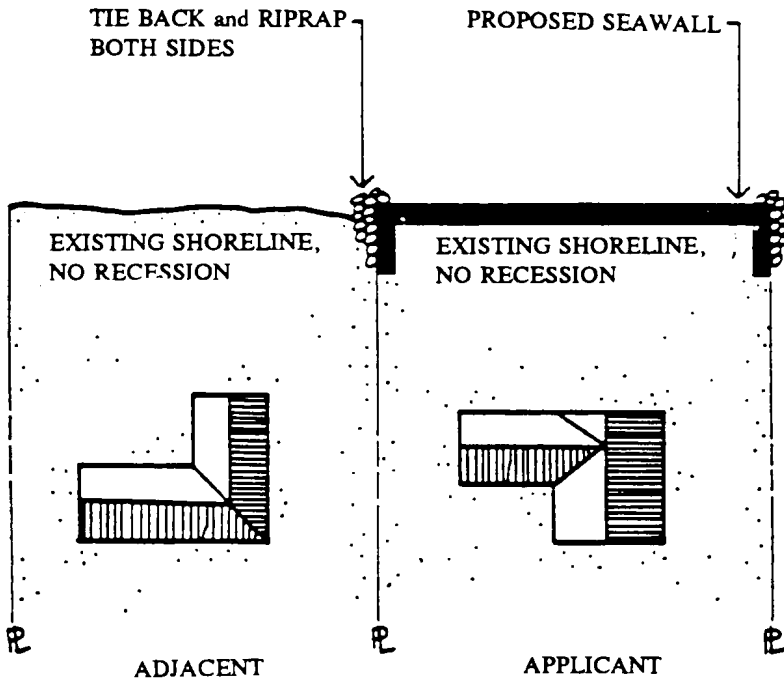
Exhibit 3

Seawalls: Four Situations and the Types of Structures Required



CONDITION ONE

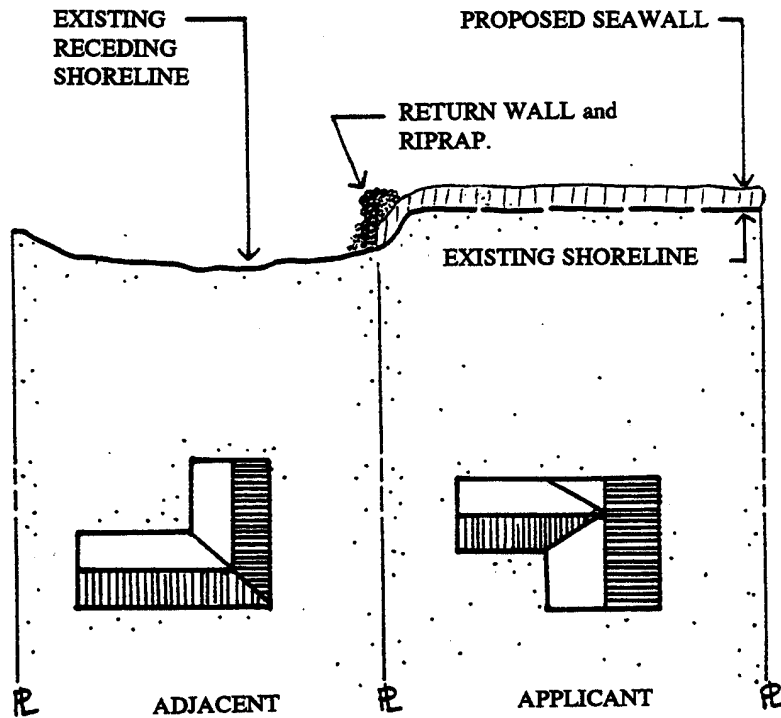
If adjacent shoreline has a seawall, a similar seawall in height and location should be used. Where possible, try to contour the new seawall with the existing shoreline, and use similar materials.



CONDITION TWO

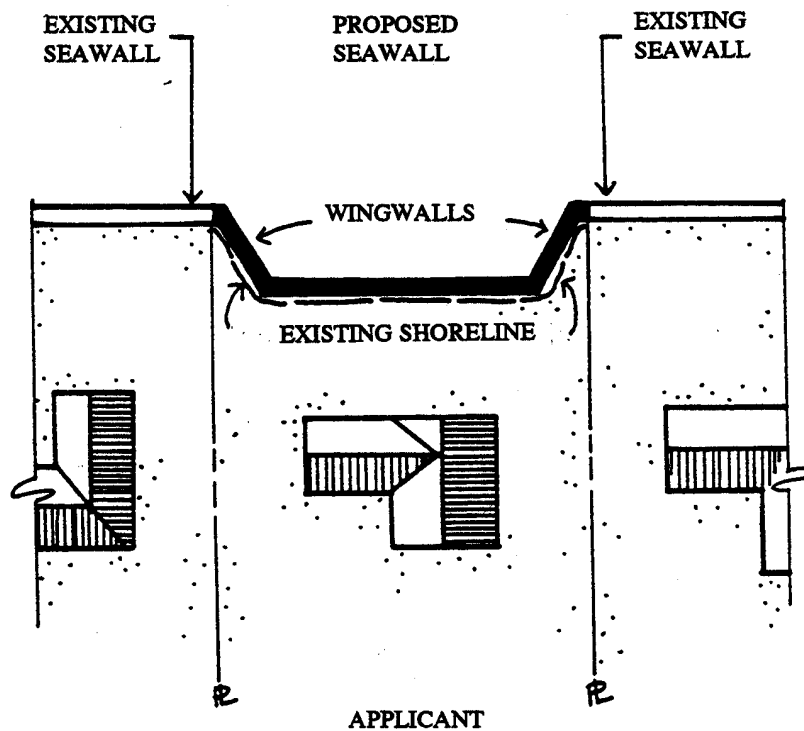
If adjacent shoreline has not recessed, a seawall parallel to the shoreline is required.

Exhibit 3 (Con't)



CONDITION THREE

If adjacent shoreline is recessed, a return wall is required.



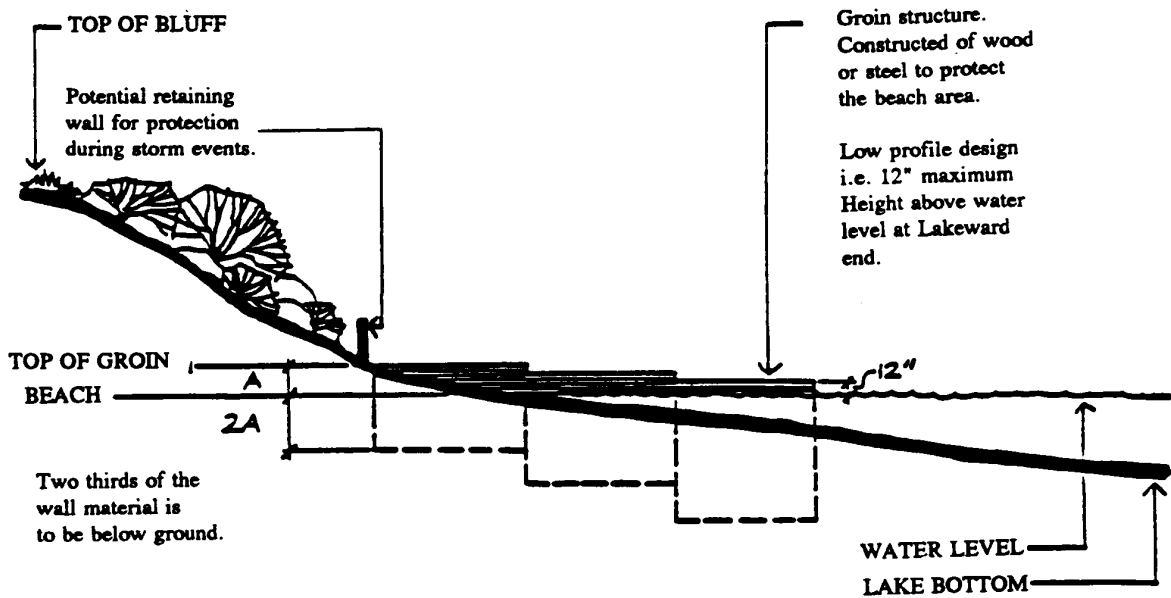
CONDITION FOUR

If adjacent shorelines have seawalls and existing shoreline has recessed significantly, a seawall with wingwalls is required.

Source: Modified from the Construction Project Evaluation Manual, Michigan Department of Natural Resources, 1987.

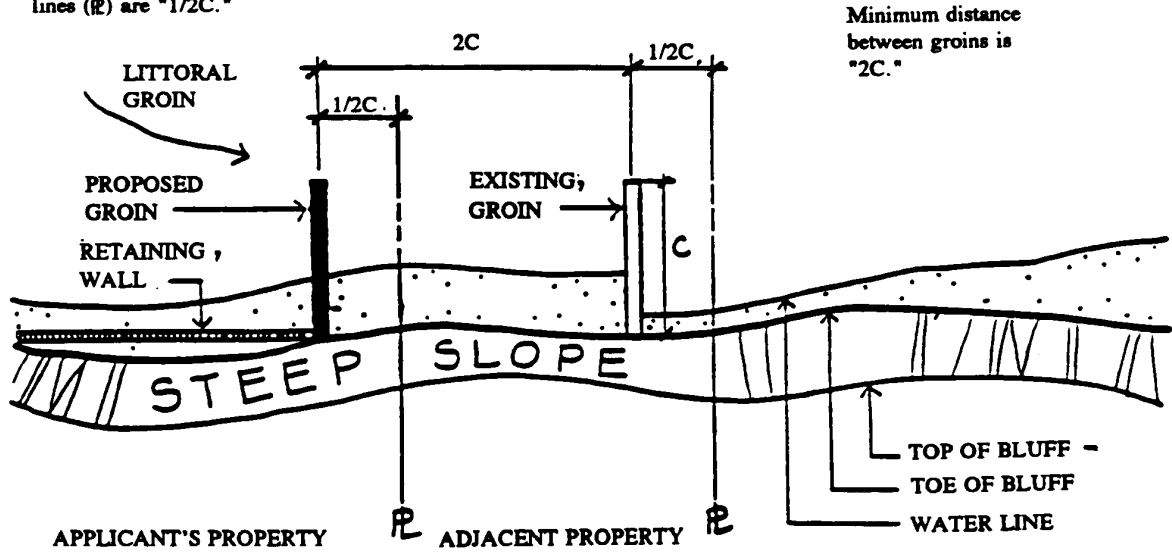
Exhibit 4

Typical Groin



TYPICAL GROIN SECTION

A proposed groin may be no longer than other groins in the vicinity (C). Unless authorized by adjacent landowners, minimum distances between groins and property lines (P) are "1/2C."

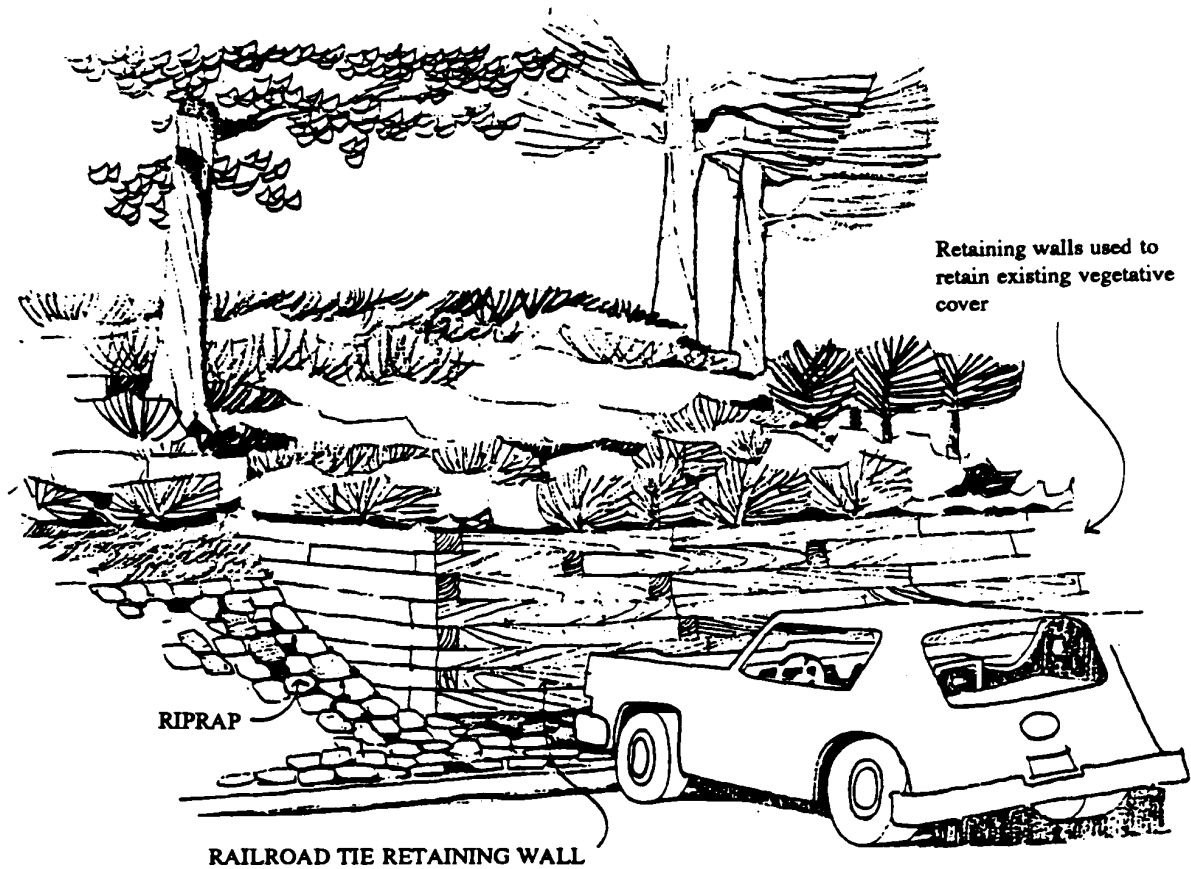


GROIN PLAN

Source: Construction Project Evaluation Manual, MDNR, Land and Water Management Division.

Exhibit 5

Retaining Wall



Source: Construction Project Evaluation Manual. MDNR, Land and Water Management Division.